Use of ash and nitrogen concentrations in manure to estimate loss of ammonia over time

Henry A. Paz and William P. Weiss

Department of Animal Sciences, The Ohio State University-OARDC

Abstract

The aim of this study was to validate a mass balance method based on N and ash in manure to estimate NH_3-N losses. Six multiparous Holstein cows were used in a replicated 3 x 3 Latin square. Three diets, corn silage (CS), alfalfa silage (AS) and corn silage + urea (CSU) with different N:Ash ratios, 0.41, 0.37, 0.47 respectively, were fed. During total manure collection, urine and feces samples were used to prepare a slurry (1200 g) in the same proportion as excreted by each cow. Slurries were incubated for 3 d. Initial and final N concentrations and slurry masses were used to determine N losses. Nitrogen loss was estimated as: (N Intake – N Milk) – [N/Ash*(Ash Intake – Ash Milk)]. Average manure output was 65.4 kg/d with cows fed AS and CSU excreting 18.6 kg/d of urine followed by CS at 14.5 kg/d (P= 0.01). Manure N excretion was highest for cows fed CSU followed by AS and CS (422, 392 and 343 g/d, P<0.01). Ash excretion in manure was highest (P<0.01) for cows fed AS (1134 g/d) followed by CS and CSU (936 g/d). Measured NH_3-N loss was 30, 41, and 70 g/3 d for AS, CS and CSU and estimated losses were 17, 31, and 75 g/3 d, respectively. Average estimated NH_3-N losses did not differ from measured losses (P= 0.15); however, method underestimated NH_3-N losses in cows with negative N balance and overestimated it for cows in positive N balance.

Key Words: Nitrogen, ash, NH_3-N

Introduction

Ammonia (NH_3) emissions from livestock farms may have negative impacts on human health (Wolfe and Patz, 2002) and the environment (Galloway, 2003). The potential impact of manure NH_3 has resulted in public concern and dairy farms now face environmental regulations that will require the ability to estimate NH_3 emissions. Even though numerous methods have been proposed to estimate NH_3 emissions from farms all have severe limitations (expensive, time consuming or impractical on farm level). Consequently, an on-farm and practical tool to estimate accurately ammonia emissions is needed. **The main objective of this study was to evaluate the use of N and ash concentrations in manure to estimate NH_3-N losses**.

•Hypothesis:

Based on the principal that ash is non-volatile and remains constant in manure but N is prone to volatilization, changes in the N/ash ratio can be used to estimate NH_3-N losses.

Materials and Methods

Diets

Table 1. Ingredient and chemical composition of diets (Dry matter basis)

	Diet		
Item	Alfalfa silage	Corn silage	Corn silage + urea
Ingredient, % DM			
Corn silage	10.1	47.5	47.5
Alfalfa silage	47.5	10.1	10.1
Concentrate	42.4	42.4	41.9
Urea	0	0	0.5
Chemical composition			
Dry matter (DM), %	67.6	59.1	59.2
Crude protein, % DM	14.8	13.1	15.6
Ash, % DM	6.5	5.2	5.3

Manure from cows fed these diets was hypothesized to differ in:

- Ash concentration (AS vs. CS and CSU)
- Urinary N (CSU vs. CS and AS)
- Fecal N (AS vs. CS and CSU)

These different excretion patterns allowed a robust test of the proposed method

Cows and Design Structure

•Eight midlactation Holstein cows

•Orthogonal, replicated 3 × 3 Latin square

•Periods:

- ➢10 day diet adaptation
- ➢ 4 day total manure collection

Collection period

- Feed samples and total output of feces, urine and milk were collected. Urine and feces were kept separate (via attached hoses in Figure 1) to avoid N volatilization (Figures 1 and 2).
- Composite samples of feed, refusals, milk, feces and urine were analyzed for N and ash to determine N and ash intake and excretion.

Figure 1. Metabolism stalls

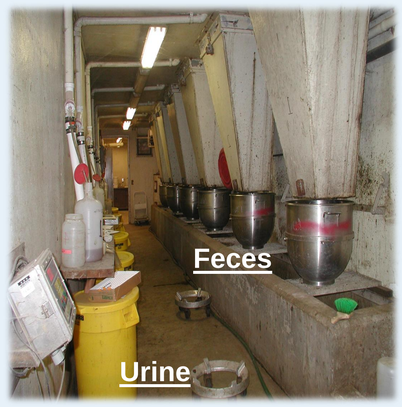

Figure 2. Total manure collection located directly below stalls

Slurry

- Urine and feces samples were used to prepare a slurry (in duplicate) (1200 g/tray) in the same proportion as excreted by each cow.
- Slurries were incubated for 3 days.

Figure 3. Slurries during incubation period.

- Measured NH_3-N losses =

  N loss = g of N in the tray on day 3 – g of N in the tray on day 0

(g of N were measured by weighing each tray and sampling the slurry and then analyzing the sample for N)

- Estimated NH_3-N losses =

  (Nitrogen Intake – Nitrogen Milk) – [(N/Ash)*(Ash Intake – Ash Milk)]

Where; Intake = daily consumption of N and ash by the cows (g/d), N and Ash Milk are g/d, and N/Ash = their concentrations in slurry samples at 3 d.

Results

Table 2. Manure production and N and ash balance of cows

	Diets			
Item	AS	CS	CSU	P-value[1]
Manure, kg/d				
Urine	18.8[a]	14.5[b]	18.5[a]	0.01
Feces	47.1[b]	50.1[a]	47.2[b]	0.04
Total	65.9	64.6	65.7	0.42
N output, g/d				
Manure	392.1[b]	342.9[c]	422.2[a]	<0.01
Feces	261.5[a]	202.7[b]	198.1[b]	<0.01
Urine	130.6[b]	140.2[b]	224.1[a]	<0.01
Milk	149.9[b]	159.9[a]	162.3[a]	<0.01
N balance	-29.98	-26.6	-14.73	0.38
Ash ouput, g/d				
Feces	619.4	548.9	555.3	0.22
Urine	515.0[a]	371.2[b]	397.0[b]	<0.01
Manure	1134.3[a]	920.0[b]	952.2[b]	<0.01
Milk	219.0[b]	228.5[a]	230.1[a]	0.06
Ash balance	30.3	17.1	30.0	0.92

[1]Treatment effect

[a,b,c]Means within a row with different superscripts differ by shown P-value.

- Feeding urea (CSU) greatly increased urinary N excretion (P<0.01)
- Alfalfa silage (AS) diet increased manure ash excretion (P<0.01) and fecal N (P<0.01)
- Corn silage diet (CS) increased fecal production compared to alfalfa silage and added urea diets (P=0.04).

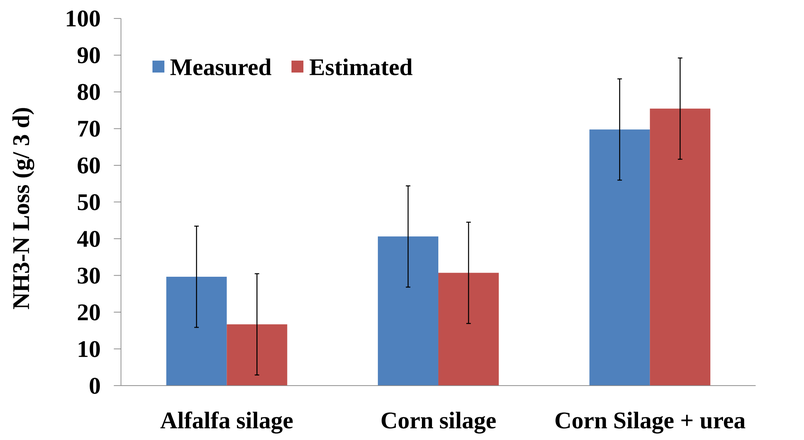

Figure 4. Average estimated NH_3-N losses did not differ from measured losses (P= 0.15).

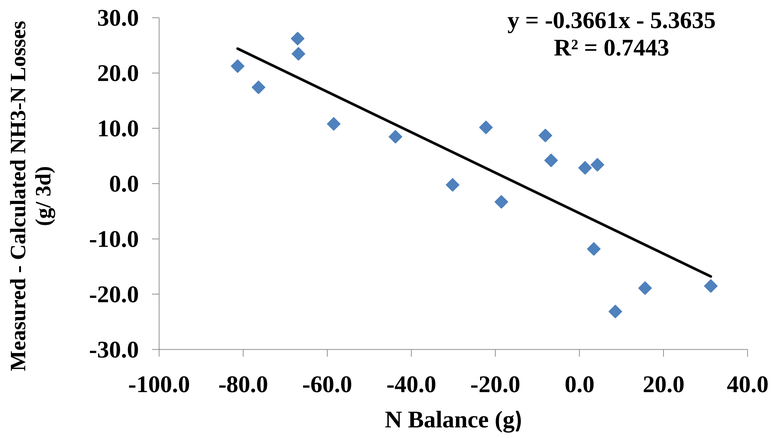

Figure 5. Estimated NH_3-N losses based on N and ash concentrations in manure underestimated actual losses for cows in negative N balance and overestimated losses for cows in positive N balance. The estimation method does not consider N mobilization or retention by the cow.

Conclusions

- **On average, the N/ash method estimates accurately NH_3-N losses.**
- **The N/ash method accuracy is influenced by N and ash balances.**
- **Feeding diets with high ash and nitrogen concentrations increases urine production.**
- **Increasing nitrogen and ash intake increases their excretion in manure.**

Acknowledgments

Special thanks to the Krauss Dairy Center crew for their support with cow management and help during the collection period and to Donna Wyatt and Tonya McKelvey for their hard work during this project. This work was partially funded by the OARDC Research Enhancement Competition Grant Program.

References

- Galloway, J. N., J. D. Aber, J. W. Erisman, S. P. Seitzinger, R. W. Howarth, E. B. Cowling, and B. J. Cosby. 2003. The nitrogen cascade. Bioscience 53(4):341-356.
- Wolfe, A. H. and J. A. Patz. 2002. Reactive nitrogen and human health: Acute and long-term implications. Pages 120-125.